Pneumothorax (PTX) is a common problem in critical care medicine as well as in soldiers on the battlefield. It is commonly associated with hemothorax (HTX). Rapid identification of pneumothoraces and hemothoraces could help in the management of patients with these problems. Early detection, particularly in the field, has the potential of aiding the prompt institution of treatment to avoid the development of tension pneumothoraces, which can be life-threatening. Pneumothorax is recognized to be associated with decreased lung sound amplitude. Computerized lung sound analysis has been shown to provide objective assessment of lung sound amplitude. Furthermore, this type of analysis can be done on small, portable computers, such as PDA’s that could be available in emergency situations.

**GOAL**

The goal of this study was to investigate the acoustic characteristics of induced pneumothoraces and hemothoraces in pigs.

**METHODS**

A swine protocol was conducted to obtain acoustic recordings from locations on the chest in supine and prone positions of various sized PTX, HTX and PHX. These data were analyzed in the time and frequency domains to study characteristic elements that have the potential of providing the basis of a PTX algorithm.

Following twelve hours of fasting, the animals received a premedication that provided adequate sedation to permit endotracheal intubation. After intubation, a surgical plane of anesthesia was maintained. The plane of anesthesia was monitored by heart rate, respiration rate and quality, and jaw tone. All sedation and anesthesia were performed by veterinary personnel or appropriately trained investigators or technicians.

PTX was produced by injection of air into the pleural space of one lung. The second lung was used as a control. HTX was simulated by injection of normal saline into the pleural space of one lung. We also studied the combination of air and saline injection into one lung to create a simulated PHX. Air and/or saline was injected in incremental amounts of 400ml and digital recordings were made of the lung sounds at each stage. We then reversed the PTX to a normal lung state and performed the experiment again on the same animal. Control recordings were performed on both lungs of each animal before experimentation had begun.

A 16 channel Stethographics Multi-Channel STG system was employed for data acquisition. A foam backpack containing 16 microphones (Figure 1) was placed on the posterior chest of the animal. Figure 2 shows the approximate placement of microphones on the pigs. Two microphones were placed on the anterior chest.

Figure 1. The foam backpack with microphones.

**RESULTS**

Lung sounds amplitude was characterized by root mean square (RMS, arbitrary units). RMS was calculated separately in inspiration and expiration. Further, RMS was averaged between all breaths present in the 20 seconds recording (normally 4 breaths). To avoid contamination from heart sounds and to minimize effect of electronic noise, sound was digitally filtered by a bandpass filter between 800Hz and 500Hz in all data analysis.

**RMS Ratio**

The effect of PTX on sound amplitude was characterized by a ratio of the RMS of the inspiratory sound of the left lung (normal) to that of the right lung (collapsed).

RMS Ratio

The analysis of data from animals has resulted in the following observations:

1. The RMS ratio is a sensitive measure of both PTX and HTX.
2. A PTX as small as 100ml changed the sound amplitude.
3. Sound amplitude, when no adventitious sounds are present, differentiates PTX and HTX lungs from normal lungs. This provides evidence that an automated algorithm for detection of PTX and HTX can be developed.
4. The development of adventitious sounds (crackles, rhonchi, wheezes, and squawks) in association with the desaturation was an unexpected finding.

**CONCLUSION**

The development of wheezes and rhonchi pointed out an important problem that needs to be addressed. It is quite possible for soldiers to develop lung injury or myocardial stunning leading to congestive failure. This could cause adventitious sounds that need to be accounted for in an algorithm for the detection of PTX. These unexpected results believe will lead us to a more powerful and useful algorithm.